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A Predictive Model for Acute Admission in Aged Population

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Abstract. Acute hospital admission among the elderly population is very common and have a high impact on the health services and the community, as well as on the individuals. Several studies have focused on the possible risk factors, however, predicting who is at risk for acute hospitalization associated with disease and symptoms is still an open research question. In this study, we investigate the use of machine learning algorithms for predicting acute admission in older people based on admission data from individual citizens 70 years and older who were hospitalized in the acute medical unit of Svendborg Hospital in Denmark.

Keywords. Predictive model, Machine Learning, Acute Admission, Healthcare, Data Science

1. Introduction

As in most countries the population in Denmark (5.75 million as of 2017) has aged significantly. Ageing is associated with an increased risk of morbidity and acute hospitalization. Not only do people live longer, the proportion of elderly becomes relatively larger. An ageing population will increase the demand for primary and secondary healthcare, and it will also be reflected by an increasing number of acute hospital ad-missions of elderly citizens [1]. Furthermore, evidence in the literature indicates that a large amount of the aged patients admitted to hospitals require home care, and further primary care physician contacts after discharge [2]. The problem of acute hospitalization among the older adults will become more significant as the population continues to age. Patients with repeated admissions use a large amount of health care resources which lead to bed shortages in clinics [3]. There is a consensus that to reduce hospital admissions the patients with high risk for hospitalization need to be identified as early as possible. Hence, these individuals could be systematically monitored and evaluated for underlying diseases and medication effects, in order to apply preventive measures to avoid further deterioration and risk of hospitalization. Much research has been de-voted to identifying risk factors in the aged population [4], but a direct

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comparison of existing studies is difficult due to lack of clarity and consistency in definitions, methodological issues, small or biased study populations, variability in the periods of follow-up, and vague symptoms.

A predictive model for identifying patients at the highest risk for acute admission and the feasibility of using these inferred likelihoods can assist physicians in clinical decision making [5, 6]. In this way, an accurate predictive model helps to reduce the number of hospital admissions. A prediction system could be beneficial to both patients and doctors. Doctors can improve medical treatments for high risk individuals to avoid acute admission and patients may avoid some of the hazards of hospitalization, such as delirium, hospital-acquired infections, and functional decline [7]. In this study, the objective is to build a predictive model for acute hospitalization among older people based on the data on health care services received from the municipality. The aim is to predict and estimate a hypothetical time for when an acute admission will be unavoidable and thereby enable early preventive actions to prevent hospitalization. This should reduce costs while at the same time improve the home care resources and the quality of life for the elderly more sensible. The remainder of this paper is organized as follows. Section 2 presents the material and describes the extracted data for this study. Section 3 introduces the method and designed model of the study. The techniques and the framework of the predictive model for acute hospital admission is presented. Finally, the paper is concluded in Section 4. We discuss the challenges in predictive models in the healthcare and illustrate the opportunities and strengths of machine learning algorithms in the medical domain in this section.

2. Material

We used data from an earlier study that was extracted data from 443 short term (<48 hours) hospitalizations at the acute medical unit of Svendborg Hospital in Denmark [1]. The unique personal number (CPR-number) identifying all citizens in Denmark enabled tracking individual data on municipal homecare and primary care physician contacts 12 months prior and 6 months post-acute admission – see Figure 1.

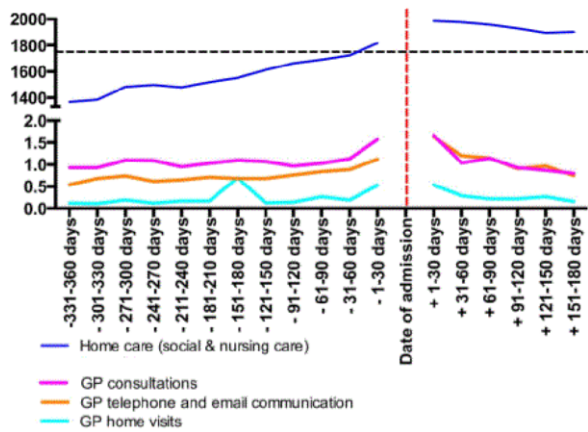


Figure 1. Average number of minutes of home care per month, and number of primary care physician contacts prior and post-acute short-term hospitalization of elderly citizens aged >70 [1]

The cohort is used to examine the association between the hospital admission of older adults and a number of other variables such as the use of home care service provided by the municipality (i.e. services time (minutes per day), nursing care, and in-home rehabilitation), primary care physician contacts, prior admissions, and a number of demographic data e.g. age, gender, marital status. The data was obtained for a period of one year prior to 6 months after each individual admission.

3. Method and Model Design

We investigated the applicability of machine learning algorithms for prediction of acute admission for the cohort. The machine learning algorithms applied the process of discovery of previously known patterns in the database and used that data to build a predictive model for new cases [8]. The most popular and essential functions in machine learning include predictive modelling. Machine learning algorithms can take advantage of medical suppliers, like clinics, hospitals, experts, and patients, by identifying efficient treatment and better actions [9]. The goal is recognizing new, valid, helpful, and logical association and patterns in data by combing large data sets to recognize patterns which are difficult for humans to discover. The modelling included the selection of predictor attributes, applying statistical methods such as cluster analysis and regression analysis to create a classifier. The predictor attributes used for creating the classifier includes demographic information of patients such as age, gender, co-morbidities and medication. Feature extraction is an important level in the development of any predictive model [10,11]. The selection of these attributes is based on evidence from the medical literature and health professional experts approving the applicability to identify the risk attributes for acute admission. Prediction attributes were validated to assess the predictive value with a classifier driven technique and regression models. Attributes are selected to bring insights into a subset of prediction variables that correlates with hospital admission of the patients. The aim is to build a classifier to predict who is going to need hospitalization, based on these attributes.

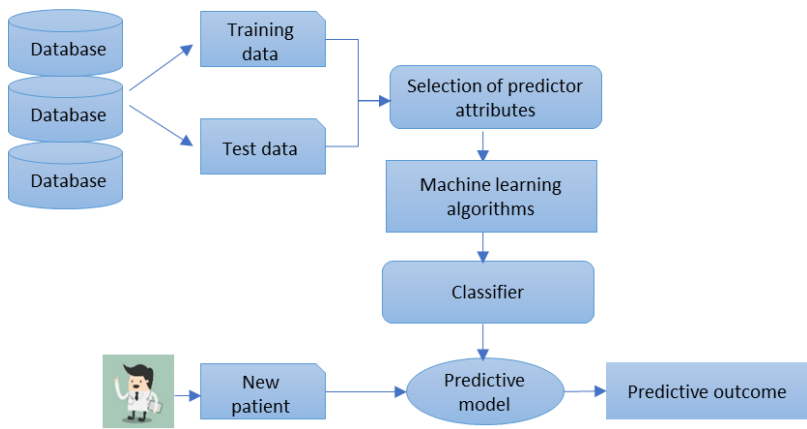


Figure 2. Framework of the predictive model for acute hospital admission

To improve the generalizability of the model, following the popular method in healthcare predictive models [11], we split the dataset into two different sections: a training section and a test section. The training part contains 70% data of the database, and the test part includes the remaining patients. The training and test datasets do not overlap. Figure 2. shows the conceptual framework of our predictive model. Python 3.6 is used for statistical analysis such as building the classifier, validation analysis, and decision optimization. Python is a powerful and popular tool for data analysis and contains all the required learning algorithms. It is more robust when using large data sets than other similar open source packages like Weka.

4. Discussion and Conclusion

We investigated how to design a predictive model for acute hospital admission in older adults based on clinical data and using machine learning algorithms. The aim was to support decisions on specific preventive actions to avoid hospitalization by identifying several predictors for assessing the risk of hospitalization. A computational predictive model to forecast future instances of the morbidity in elderly patients can help to improve the quality of healthcare [12, 13]. However, the modelling itself face some challenges as the model must exhibit high accuracy to be applicable in the clinical work. Although, many predictive models have been developed and validated using large datasets, less attention has been considered to ensure sufficient reliability when the model is applied in decisions concerning an individual, which exactly is critical for point-of-care decisions [14, 15]. Model based predictive estimates are always very context sensitive and careful attention must be exercised when systems are transferred to different environments. This study is conducted at Svendborg Hospital in Denmark, using local data as training data as well as test data, thus, its performance may not be as good in other settings. Correlations within clinical data might not vary significantly between settings, this model however, apply essential data from homecare visits, rehabilitations, and primary care physicians – different health services which are specific to structural issues in the Danish health care sector. Applying health prediction rules across settings and to new individual patients is always challenging because of different symptoms, multiple conditions or polypharmacy, ageing physiological diseases, high risk of complications, or risks of complications. Hence, validation of the rules should always be in agreement with specific healthcare systems or hospitals. The predictor attributes affect the composition of the model development, for example, all patients are not being evaluated based on the same laboratory tests. Some attributes have limited representations in the predictive model. Therefore, it could be concluded that, a more transferable model with higher efficiency is achieved by applying fewer context sensitive attributes associated with specific health environment. With under-standing which specific individuals and conditions we're facing would help to offer better home medical treatments with the most benefit. Moreover, when machine learning algorithms gain knowledge from the human decisions, they also learn or replicate human mistakes, like overdiagnosis, overtesting, failing to realize patients who need to care, and mirroring ethnicity or gender biases. Ignoring these contents will result in automating and even magnifying challenges in the healthcare system. Knowing all these challenges demands a deep knowledge with the medical decisions and the data they generate, a reality that emphasizes the significance of viewing machine learning algorithms as thinking partners, rather than replacements, for physicians [16].

In our future work, we will implement a predictive model for acute hospital admission based on the proposed framework and evaluate the performance of the predictive model through a cross validation. Employing the predictive models will assist the physicians in making decisions and enable better treatment earlier, and a major driver of cost by decreasing the incidence of hospitalization.

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